Life Cycle Thinking - the case of Grundfos

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Abstract
This article describes how environmental life cycle thinking (LCT) has been implemented by Danish proactive companies over the past two decades. Particular attention is given to the experiences obtained by the Danish pump manufacturer Grundfos. It is argued that life cycle assessment (LCA) can be a good point of departure for integration of environmental considerations in product development, but the LCA tool also has its limitations. LCA is sometimes given too much attention, and the experiences from Grundfos shows that other and more improvement-oriented tools are necessary to foster innovation of greener products in the long run.

Grundfos is currently in the process of implementing a structured and organized approach towards Ecodesign, while being challenged with the implementation of corporate social responsibility (CSR). Hence, apart from analyzing the experiences with LCT in a historical perspective, the present article also seeks to discuss future challenges and possible strategies to promote sustainable processes and products at Grundfos.

Key words: Life cycle thinking (LCT), Life cycle assessment (LCA), Ecodesign, Product development, pumps.

1. The concept of Life Cycle thinking

1.1 Life Cycle Thinking, Ecodesign and LCA

Life cycle thinking (LCT) is an ambiguous concept with many connotations. In this article we will refer to LCT as an approach to assess and/or reduce the environmental problems related to the life cycle of products or services. LCT should ideally cover the entire life cycle, and can also be used in relation to social and economic aspects.

In relation to the environmental dimension LCT can be implemented in companies through 'strategies' for cleaner products, through management 'systems' (such as ISO 14001) or through 'tools' such as Ecodesign and Life Cycle Assessment (LCA). The main focus of the current article is the tool level, but it is important to notice that life cycle thinking and development of cleaner products requires initiatives at higher management levels as well.

LCA is a relatively specific tool for environmental assessment of products or servicec. It can be conducted at many levels of detail, but in practice it often refers to relatively detailed studies based on the ISO 14040 and 14044 standards. Even though Ecodesign also includes elements of 'assessment' this tool is much more focused on generating

ideas for 'improvement'. The International Organization of Standardization (ISO) describes Ecodesign as:

"the integration of environmental aspects into product design and development" (ISO/TR 14062, 2002).

The differences in characteristics of Ecodesign and LCA are illustrated in table 1.

	Ecodesign characteristics	**LCA characteristics**
Purpose	Improvement	Assessment
Approach	Creativity and innovation	Details and documentation
Time requirements	Fast to use (takes time to implement)	Time consuming
Users	Lay people, product developers, R&D	Experts, environmental department
Data and information	Qualitative	Quantitative
Norms	Guidelines	Standard

***Table 1**: Differences between the Ecodesign and LCA approaches.*

The ultimate goal should obviously be improvement in both cases, but the improvement part is not treated explicitly in LCA even though LCA is a good basis for improvements or development of Ecodesign tools that address the hot-spots of a particular product type[1]. Another difference that isn't mentioned in the table, is that Ecodesign is more focused in management, because one of the big challenges is implementation, while LCA is something you 'conduct' and which is not necessarily fruitful to implement organization-wide. It should be obvious that LCT has many 'faces'. It is a concept that is used in many contexts, at different levels of detail, at different management levels and for both improvement and assessment.

This article will provide a short overview of the development of life cycle thinking in Danish companies during the last two decades and provide a case study of the experiences at the Danish pump manufacturer Grundfos A/S, with a focus of the development in their approach towards LCT, their current status and possible future strategies for integration of LCT in product development and other areas of the organization.

2. Development of LCT in Denmark

The notion of cleaner products and life cycle thinking was introduced in the Danish Environmental Protection Act – already in 1982. However, the main focus of cleaner production during the 1980ies was the immediate environmental impacts inside the company's fence.

[1] A large European study recently showed that companies engaged in LCA most frequently uses it for hot-spot assessment and documentation - but relatively seldom for design of eco-friendly products (Rubrik 2002).

2.1 The rise and fall of detailed LCA in companies

During the 1990s, however, substantial efforts were made to promote life cycle assessment (LCA) through the development of EDIP (Environmental Design of Industrial products) in the period 1991-1995. The EDIP method, which mainly focused on LCA, was tested in five industrial enterprises; Danfoss A/S, Grundfos A/S, KEW A/S, Gram A/S, and Bang and Olufsen A/S (Wenzel, Hauschild, and Alting 1997). Initially it was the ambition to obtain a relatively broad diffusion of LCA among Danish companies, but the combination of thick (and relatively advanced manuals) and unreliable software solutions, appears to have been a barrier for broader diffusion[2].

In the new millennium more funding has been allocated to further develop the EDIP method into the so-called consensus project, but this has not been a step towards further diffusion[3]. Although the consensus project was relevant, a negative side effect has been a further distancing between LCA experts and the companies who appears to have become decoupled from the 'academic' discussions about advanced LCA modeling. Some projects have been initiated during the last five years to promote life cycle thinking, streamlined LCA and Ecodesign but generally Ecodesign has gained little attention and funding.

Today, in 2008, most Danish companies still only address environmental impacts inside the companies' fence (the onsite emissions) due environmental approvals that focus on air and wastewater emissions and solid waste. In round numbers, there are approximately 10,000 Danish companies that mainly focus on emissions and waste generation. In comparison, there are roughly 1,000 companies that have implemented an environmental management system (with a broader scope than onsite emissions), while it is around 100 companies that apply life cycle thinking in their environmental work. We would estimate that 10 companies actually conduct LCA. The big question is also whether companies need to do LCA or if ecodesign and simple assessment tools such as carbon footprinting is enough in most cases.

2.2 New incentives for Ecodesign and streamlined

Currently, there are signs of reinvigoration of both (simple) LCA and Ecodesign in the industry. First of all we see a regulation pressure through EU directives such as the Rohs, WEEE and EuP directive – providing new insensitive for Ecodesign as well as LCA. In addition, the strong focus on global warming creates an impetus for the use of LCA tools in a new way, with stronger focus on the carbon footprint. This could also be termed single issue LCA. A new standard is being developed for carbon footprint analysis, the PAS 2050, and large retail companies in UK and Sweden are currently announcing carbon labeling of large product groups (Weidema et al. 2008). Together with the development within energy labeling and environmental product declarations, there are signs, which points towards a greater dissemination of both streamlined carbon footprint oriented LCA and Ecodesign in the near future.

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[2] The EDIP project did in fact include a tool book that focused on product development and Ecodesign, but it never got the attention that it might deserved. Also, it could be argued that it was still too advanced with too many references to the 'universe' of LCA.

[3] One of the results of the consensus project is that we in Denmark have built a consensus around the so-called consequential approach towards system modeling in LCA.

The following include a case study of the development in the environmental work at the Danish pump manufacturer Grundfos A/S.

3. Towards Improvement Tools and Processes at Grundfos

Grundfos is one of the worlds leading pumps producer with an annual production of more than 16 million pump units. The company is best known for circulation pumps, and Grundfos is the world's largest producer of circulation pumps and approximately 50 % of the sale of circulation pumps is covered by Grundfos. Besides circulation pumps Grundfos produces many different types of pumps for industries. (Grundfos 2008)

3.1 Environmental work at Grundfos since the 1990s

Grundfos has worked with environmental considerations for many years. Niels Due Jensen, the Group President at the time, signed the Business Charter for Sustainable Development in the beginning of the 1990s. The first environmental policy was formulated after the commitment to the Business Charter. The following years the environmental work became more and more systematized. In 1996 the first Grundfos production companies were certified according to the environmental management system (EMS) standard ISO 14001 (Ballisager 2007). Over the years, the EMS created awareness of the environment and many improvements were made. Today the EMS is continuously updated and maintained. Parts of the production sites are also certified by EMAS, and Grundfos was awarded with the prestigious EMAS price in 2007. (Grundfos 2007)

Experiences with life cycle oriented environmental work
Grundfos has also been one of the first movers when it comes to environmental considerations in product development and the company participated in the EDIP (Environmental Development of Industrial Products) project from the beginning of the 1990s (Grundfos 2007). The participation in the EDIP project gave Grundfos opportunities and means to work with cleaner products and Grundfos obtained important knowledge about their products environmental profile from an early point. As it turned out, energy use was a crucial issue (Wenzel 1996). LCA studies was carried out on several products at the end of the 1990s, and it turned out that 70-98% of the total impact on the environment is caused by the use phase of the circulation pump (Theisen and Remmen 2008). A timeline of the main events in Grundfos environmental work in the period after 1990 is provided in figure 2.

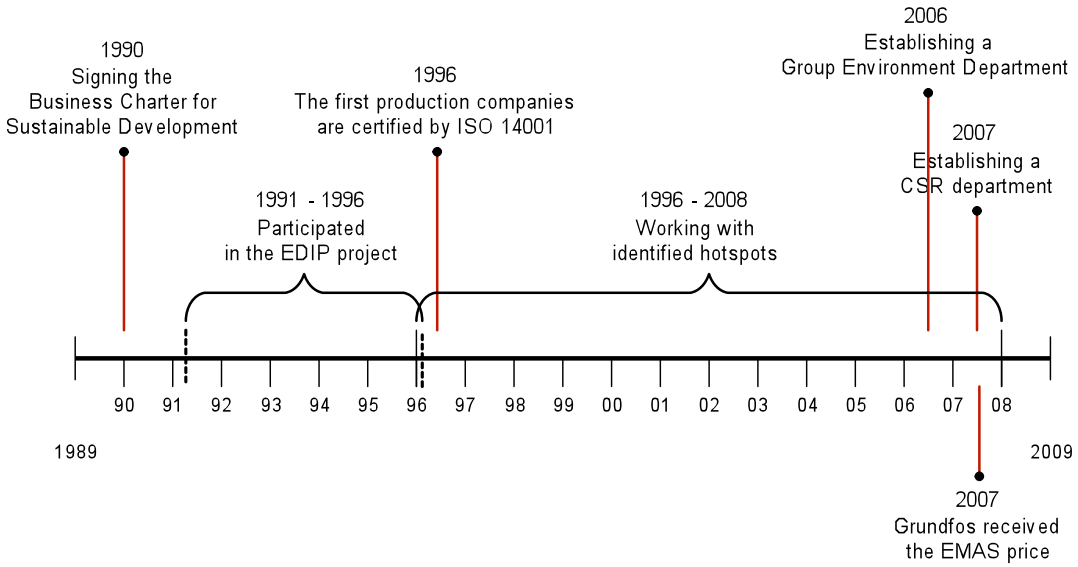

Figure 2. *Main events in Grundfos' environmental work in the period after 1990*

LCA became a part of the formal product development process (PDP) in this period and it was a requirement that LCA's was performed in the last half of the 1990s – for internal purposes. However, even though the project was supported by a project team, only one person from Grundfos was responsible for the EDIP project in the whole period, and the LCA knowledge became person dependent (Grundfos 2007). The responsible person was after a while given other tasks in the company and the LCA capacity was weakened. One of the lessons learned from the EDIP project seems to be that future projects should be less person dependent, more integrated and more focused on improvement oriented tools with a broader audience. However, the learning process in the participation in the EDIP project is of significance, because it created knowledge about the environmental impacts in the entire product life cycle, and the company is still working with life cycle perspectives in the product development process. Some of the main successes from the use of LCA are the identification of hotspots, which all the product development projects have to consider – in this way the LCA results are directly used in the daily work in the development projects, also today (Grundfos 2007).

Examples of green innovations

Grundfos initiated a project aimed at reducing the energy use of existing state-of-the-art circulation pumps for household heating systems, already in 1992. A combination of industrial researchers and engineers at Grundfos where assigned to the project, which resulted in a range of new solutions and patents. The knowledge obtained from the project resulted in the development of a new and much more efficient pump Alfa Pro in 2005. It was estimated that the energy saving potential for this pump was roughly 40 TWh in EU-25 if all D-labeled circulations pumps where changed to Alfa Pro standard. In 2007 Grundfos launched the successor to Alfa pro – called ALPHA 2, which is more compact, more user-friendly and optimized for mass production (Theisen and Remmen 2008).

The time gap between initiation of the development processes in 1992 and the product launch in 2005 is explained by a lack of market pull in the previous period. Despite the use of LCC studies which clearly showed a reduced 'total cost of ownership' for

the new pump type - consumers didn't react before the introduction of the new energy labeling system for pumps. Grundfos had played an important role in relation to criteria development and generally promoted the energy label through the European association of pump manufacturers Europump (Theisen and Remmen 2008). Both the involvement in the innovation project aimed at improving energy efficiency as well as the involvement in the energy labeling system – was strongly promoted by the top-management at Grundfos and the case shows that cleaner products also can be obtained without detailed LCA and Ecodesign procedures.

3.2 The Environmental Work at Grundfos Today

The focus on environmental considerations and life cycle thinking in product development at Grundfos has further increased the past few years. Energy is still very important but also other issues are to be considered – both related to the environment and related to social aspects.

The extended focus has among other things resulted in the establishment of two new departments: 1) A Group Environment Department, 2006, and 2) A Group CSR Department, 2007. The Group Environment Department was among other things established because of an increased global marked, an expanding business, and a larger focus on the environment which required a department to handle environmental aspects (in a life cycle perspective) at a global level. One of the areas the Group Environment Department handles is environmental consideration in product development (Grundfos 2007).

Development of a more systematic Ecodesign approach
To further enhance the awareness and the effect on environmental aspects in product development, several activities are initiated including a PhD project conducted in collaboration with Aalborg University and DTU. The purpose with the PhD, is to further integrate environmental considerations in the product development process through the use of different Ecodesign related tools. The development and implementation of tools is an ongoing process and is carried out in collaboration between Group Environment and product developers.

As part of the process it has been decided that all development projects should have an up-start workshop in the idea and pre-study phase, focused on the environmental aspects. The intention is that the up-start workshop should provide a discussion and assessment of the environmental aspects that are (or could be) relevant for the specific product. The workshop should provide an environmental profile of the product as well as overall environmental goals for the product. The environmental profile is not supposed to be a result of a detailed LCA, but a semi-quantitative assessment based on the spider-web approach. The spider-web is inspired by the ECO-wheel (and other Ecodesign guidelines) but adjusted to fit the environmental goals and priorities of Grundfos as well as requirements from legislation and stakeholders. The environmental profile is used as a reference when considering environmental aspects in the subsequent phases of the product development process.

In the sub-sequent phases 'pre-study' and 'concept development' it is the intention to implement Ecodesign tools that can assist the product developers in achieving the en-

vironmental goals set up in the previous start-up workshop. Grundfos already uses a 'design for assembly' tool in this phase of the PDP, and it is the intention to integrate the new Ecodesign tool in the existing framework for design for assembly.

In the following 'development-' and 'preparation phase' it is the aim to use tools that are more focused on assessment and documentation. The details have not been decided yet, but the documentation will vary, depending on the demands from customers and legislation. Examples of tools that will be considered in these phases of the PDP are: Carbon Footprint, Life Cycle Assessment (LCA) and Environmental Product Declaration (EPD).

At this point of time (2008), the intention is that the three Ecodesign related activities should be integrated in the development process as illustrated in figure 3:

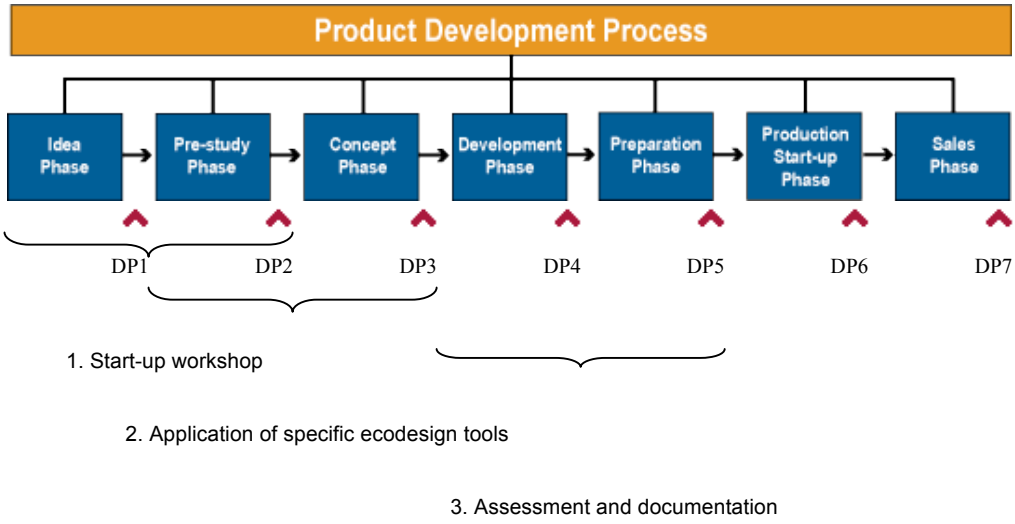

Figure 3. *The implementation of environmental considerations and life cycle thinking in product development*

The overall purposes with the Ecodesign activities are to open up for discussions about new possibilities and solutions (with a focus on the products life cycle) and to provide better guidelines for possible improvements, -prioritization, and -documentation.

The choice of activities and tools are based on the criteria that it should be relevant and usable in the daily work. The activities and tools should be integrated in processes (or tools) that already takes place and the work have to make sense for the developers – both theoretically and in practice. In order to do this, the goals and tasks must be related to the specific projects, because the projects and products can have different environmental profiles and different opportunities for environmental improvements.

The first steps towards implementation of the environmental activities are being taken at the moment. In this regard, pilot tests are conducted in selected development projects. Through these tests, it will be possible to investigate how the activities fit the company and the necessary adjustments will be made – both in relation to the selec-

tion of specific activities and tools, how they are used and where they are used in the PDP.

3.3 Future Challenges

The three suggested Ecodesign activities are a point of departure for further integration of environment considerations in the PDP at Grundfos. The goals of reducing energy use and material consumption are not something completely new to the product developers, but the ambition level for integration of environmental considerations in the PDP will be higher in the future.

The increased focus on Ecodesign will challenge the behavior and way of thinking about the environment – and therefore also be a pedagogical challenge for the environmental department. However, the support from top management and some dedicated employees creates the conditions for making it happen. The history has shown that Grundfos is capable of developing new technologies and products that reduce the environmental (and carbon-) footprint of the company significantly – without detailed procedures for Ecodesign, but not without employee commitment, creativity and support from the top-management. An obvious challenge is to develop and implement tools that further enhance the spirit and the creativity of the employees rather than becoming a bureaucratic obstacle for innovation.

Future challenges also include the question of integration of social considerations in the PDP. Negative social impacts in relation to suppliers is a possible threat to Grundfos - and in the other end of the life cycle, pumps can be used for purposes that have both positive and negative impacts in relation to environmental and social aspects as well. But so far the job is to take ‘one step’ at the time, and to create a solid basis for further expansion of tools and objectives.

LCA has not got so much attention recently in Grundfos and maybe in the industry in general. However, there are signs that some market segments has started to request LCA documentation – a development that is partly related to the advances within environmental product declarations, and partly related to the Carbon Footprint hype. Hence, it is most likely that Grundfos will increase its capacity on LCA in combination with ecodesign.

4. Conclusion and perspectives

The story of Grundfos, it the story of an environmental conscious company that has worked with management systems and life cycle thinking during the last two decades at least. LCA was the point of departure for integration of life cycle thinking in the early 1990s and the company acquired knowledge about environmental hot-spots, that has been highly usefull. LCA, however, requires competencies, which to some degree was lost over the years – partly because the LCA knowledge was related to one person. Also, it become gradually clearer that LCA should not be the only focus. Today the strategy is to increase the focus on ‘softer tools’ such as ecodesign that are more appealing to product developers and more focused on generating ‘improvements’. The advantage of ecodesign is that it is a toolbox approach and that different types of tools, including LCA, can be used for different purposes and at different stages in the

product development process. Also, ecodesign is more appealing to non-environmental experts due to its qualitative or semi-quantitative nature. But, the experiences so far show that it is not necessarily easy to develop an ecodesign strategy and to work with ecodesign in a meaningful way. One of the challenges is that more people have to be involved and therefore also educated. Also the ecodesign requirements have to be balanced with a range of other product requirements, and it should be possible to measure the improvements that are obtained. Finally, it is a challenge to develop specific ecodesign guidelines in a company where it is commonly know that the environmental hot-spot is the use phase and the energy consumption.

The case shows that it might be a larger challenge than expected to work with ecodesign in a structured and meaningful way in a large organization. And this highlights another point, namely that ecodesign also must be integrated gradually, step-by-step. Nevertheless, it can hardly be questioned that ecodesign is needed and that LCA has limitations when it comes to design processes which is where the most significant changes can be made, development of new product ideas, product service systems etc.

Grundfos is not a special case, but is a typical example of how life cycle thinking has been initiated in Denmark – namely by promoting LCA. This has been good in some ways, but it could maybe have been more fruitful to begin with some ecodesign and then introduced LCA as one o the tools in the ecodesign toolbox, later. The case also highlights the need for long-term strategies, capacity building related to more than one person and a continuous step-by-step approach instead of a stop-go-stop-go approach.

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